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AMERICAN CYANAMID COMPANY
ENGINEERING AND CONSTRUCTION DIVISION
PROCESS ENGINEERING DEPARTMENT
ENVIRONMENTAL ENGINEERING SECTION

FINAL REPORT ON EVALUATION OF ENVIRONMENTAL POLLUTION CONTROL MEASURES FOR COPPERAS PILE RUNOFF

PIGMENTS DIVISION
PINEY RIVER PLANT

JOB NO. EC-1058

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EXHIBIT 2

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SUMMARY:

At the request of the Pigments Division, ECD has been chartered to provide engineering consultation on the abatement of pollution from the copperas storage pile and acid sludge ponds. This request included field studies needed to characterize and evaluate hydrogeological conditions at the plant, technical evaluation of alternate control methods and development of basis of design for control systems.

This report presents ECD evaluations and recommendations of alternatives for control and/or disposal of acid-iron wastes entering the Piney River including the preferred conceptual approach and a preliminary basis of design.

INTRODUCTION:

A report entitled, "Preliminary Evaluation of Environmental Pollution Control Measures for Copperas Pile Run-Off" was issued by ECD in March, 1971. The reader is referred to the March Report for a description of the pollution problem in detail. That report presented a review of the control options available and a preliminary program of investigation for solving the copperas pile run-off problem. The present report considers these same alternatives and several additional ones, such as ocean disposal, suggested by Pigments Division personnel. While all the alternatives are discussed herein, only the main ones are presented in detail.

All reasonable approaches considered by ECD, their technical and economic feasibility, and the anticipated regulatory acceptance are presented in four parts and summarized in four tables:

Table I .... Control In Place

Table II .... Relocation for Solids Disposal

Table III .... Liquid Disposal Methods

Table IV .... Ocean Disposal

Supporting, explanatory information for these Tables is given in the Review of Control Alternatives associated with each Table.

Virginia State water quality standards for the Piney River are listed in Table V.

CONCLUSIONS AND RECOMMENDATIONS:

1. The most economic solution for disposal of the copperas pile would be to move the material to a suitable site, such as the Existing Tailings Pond, and bury it under a clay cover. Cost estimates for this alternative are summarized in Table II. This disposal method is considered permanent; future recovery of copperas from the disposal site could not be guaranteed.

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2. Based upon hydrogeological considerations, a short term (5 to 10 years) method of eliminating the contaminated water entering the river would be to consolidate and cover the pile in place. This method is recommended only if Pigments Division wants to keep the copperas available for a future commercial process, such as Magnetic Iron Oxide. This approach could also serve as a long term solution, but would require a commitment to continued surveillance and maintenance, and repair as required. Tables I and II summarize this alternative.

3. The production of Magnetic Iron Oxide or Precursor if and when commercially feasible, by reuse of these solid wastes would mean a reintroduction to the nation's economy of a valuable natural resource, and thereby become a positive pollution control measure. This approach would also probably be the most acceptable to the Virginia Water Control Board.

4. The acid sludge deposits must be moved to the Existing Tailings Pond or quarry for ultimate disposal as a necessary adjunct to disposal of the copperas pile in order to meet the water quality standards of the Piney River.

CRITERIA:

The Tables herein summarize three key considerations of each alternative: technical feasibility, economic feasibility, and regulatory acceptance. These are best judgments rendered by the Environmental Engineering Section of ECD and have not been assessed outside the Company.

The principal criterion used by ECD in evaluating alternative control methods is that the preferred solution must be acceptable to regulatory authorities. Consequently, the solution must be permanent. It is our understanding that Pigments Division and Corporate management also desire a permanent solution to the problems posed by the copperas pile and acid sludges at Piney River.

Basis of Costs

The Tables present capital costs for the alternatives considered to date. The sources of the capital cost information presented in these Tables were:

1. Piney River Plant (Mr. J. M. McConaghy).
2. ECD, Cost Engineering Department.
3. ECD Files (Memo - G. P. Ferrigni to W. Berry, dated January 19, 1972).
4. Cyanamid Transportation Department.

These capital cost estimates were derived by the Environmental Engineering Section of the Process Engineering Department from the above sources for purposes of preliminary economic evaluation and relative cost comparison only, and are not presented as official ECD cost estimates.

Revised 8/3/72

REVIEW OF CONTROL ALTERNATES

I. Control in Place:

A. Hydrogeological Considerations

The copperas pile lies on the side of a hill and just above a dammed stream bed. The rain which falls on the pile drains through the pile, becomes contaminated with copperas and eventually reaches the river both as surface runoff and contaminated groundwater.

Characterization of the surface runoff was done by Pigments Division personnel with assistance from ECD.

The degree to which contaminated groundwater contributes to the pollution problem was determined by a monitoring well program. The firm of Geraghty and Miller, Inc., groundwater geologists, was retained by ECD to provide consulting services on this monitoring program. The results of the program showed that the groundwater flow was slow and contained a significant concentration of acid-iron contamination. Hydraulic properties of the ground were determined to a limited extent.

The main conclusions reached in this program were that (a) the contaminated groundwater originates from rain falling directly onto the pile and not from surrounding groundwater entering the pile, (b) the surface and subsurface strata beneath and downhill from the pile is saturated with copperas solution due to the past long term leaching process, (c) upon removal of the copperas pile it will take some 7-14 years for the copperas in the soil to be washed out by rainfall and reach a level where no significant contamination of the river occurs, (d) due to the geological nature of the subsurface strata there is no practical way to hasten removal of the contaminants, and (e) the acid sludge deposits should also be removed.

Geraghty and Miller, Inc. estimated in their report that 500 gallons per day of contaminated groundwater will enter the Piney River for 7 to 14 years after the copperas pile is removed. Based on an analysis of water taken from Test Well No. 2, the acidity of the groundwater is about 3.3% measured as sulfuric acid. During periods of low river flow (e.g., 1966) the 500 gpd groundwater seepage into the river could depress the river pH to approximately 5.0, or lower. As noted previously, however, there is presently no practical way to remove this contaminated groundwater. Only time will cure this problem.

B. In-Place Control Measures

1. Pile Consolidation

Consolidating the pile is the first essential step toward control in place.

The pile can be consolidated from 7 acres to about 4 acres. It would cost $17,424/acre to cover vs the $11,200/acre to consolidate the pile.

2. Surface Sealing

Surface sealing would be the second step necessary for control in place. The following factors must be considered, however, in evaluating the effectiveness of surface sealing.

(a) Sealants do not provide a permanent brarrier to water. Therefore, they must be considered as a temporary control measure at best, i.e., periodic replacement of the seal will be required.

Films such as PVC, synthetic rubber, etc., are impermeable to water for several years. Leaks can be expected to occur, however, due to deterioration of the seams, burrowing animals, and localized settling of the copperas pile. Continuous maintenance may, therefore, be necessary.

Discussions by ECD and Piney River personnel with vendors of these materials indicate that the normal life expectancy is about 6 to 8 years. The maximum guarantee which could be obtained from vendors solicited was 5 years, since leaks result from general deterioration due to the weather. Therefore, synthetic liners and covers are not recommended as a permanent means of sealing stored copperas.

3. Physical Cover

A physical cover such as earth would be the third step for effective control in place.

An earthen cover on the consolidated and sealed pile would help protect the synthetic film from damage due to wind and freezing conditions. The earth fill would need to be at least 3 ft. thick to allow installation by a tractor and associated equipment. An earthen cover would be recommended for use with sealants or films.

4. Drainage By-Pass

The fourth step required for effective control in place is surface water drainage improvement.

Natural springs are located to the rear of the copperas pile which continuously leach copperas into the river. A permanent diversion ditch would be needed, therefore, to prevent this leaching. No significant leaching by other sources of groundwater occurs.

Regulatory Acceptance

ECD believes that the regulatory authorities would accept the "Control-in-Place" alternative only as an interim solution due to the limited life of the surface sealing, unless a commitment is made to provide continuous maintenance. Monitoring wells would be needed below the pile to continuously demonstrate satisfactory performance of this method.

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TABLE I

CONTROL IN PLACE

Process	Technical Feasibility	Economic Feasibility: Capital Cost	Economic Feasibility: Capital for Preferred Method	Regulatory Acceptance
1. Pile Consolidation (7 → 4 acres)	Excellent	$33,500	$33,500	
2. Surface Sealing				
(a) Sealants	Poor N.P. (See Note 1)			Acceptable as <u>Interim</u> Control with Monitoring
(b) Films				
Synthetic Cover (203,750 ft.^{2}) $.40/sq.ft. installed	Fair to Poor N.P.	81,500	81,500	
3. Earth cover over film 3 ft. thick by 4.68 acres at $.40/cu.yd.	Fair N.P.	9,100	9,100	
4. Drainage by-pass required for all above schemes	Good	18,500	18,500	
Total			$ 142,600	

Note: N.P. = Not permanent means of preventing leakage of water into and out of pile.

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Control in place should be considered only if Pigments Division wants to retain the copperas pile for possible use in the next 5 or 10 years by a commercial process such as Magnetic Iron Oxide, or if Cyanamid is willing to commit itself to continuing surveillance, maintenance and repair of the pile cover.

Estimated Cost

The estimated cost for consolidation of the pile, providing a film cover with 3 ft. of earth over it and improved surface drainage is $142,600. The breakdown of these costs is given in Table I.

II. Relocation for Solids Disposal or Reuse

A. Control Requirements

Disposal by relocation of the copperas pile must provide for permanent pollution control in order to be given serious consideration. The requirements which must be satisfied are (1) the site should be near enough to the present pile to permit economic relocation, (2) the site should be acceptable to the State as a permanent location and (3) the risk of both groundwater and surface water pollution must be minimal.

B. Pit Disposal

1. Review of Options

To implement this solution, the entire pile of copperas would have to be moved to a disposal pit. The latest survey (May 3, 1972) indicates that there are 150,000 tons of this material in the pile. Several sites have been considered. These are:

(a) The Quarry used for water storage located just across the river from the plant offices. Several flowing springs are reported to be located in the Quarry. These would have to be sealed or diverted prior to use.

(b) The Existing Tailings Pond provides a promising location. If the copperas is to be relocated, however, and kept in reserve for possible future recovery by the Magnetic Iron Oxide process, this tailings pond would be needed for storage of effluents from that process. It would also be required as a settling pond for treated wastewater from a neutralization/oxidation treatment process. (See Section III-B, page 10)

(c) Whitehead's Hollow, a dammed gully, reasonably close to the pile which has been used to store water for plant use. The Magnetic Iron Oxide process would require this water storage facility. Little site development work would be required.

(d) The Abandoned Tailings Pond, directly across the river from the copperas pile. Presently groundwater flows through the tailings, then through a break in the dike and into the river. An impervious liner and an impervious cover would be needed plus some site development. The proximity of this pond to the Piney River makes it a relatively undesirable disposal site.

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(e) The Camden Mine, about 3 miles from the plant. Water from this mine drains to Maple Run Brook, a tributary of Piney River. The cost of transporting the copperas would be about $75,000 and drainage to the brook would have to be controlled.

(f) The Wood-Tucker Mine is about 3 miles from the plant and drains to Indian Creek. Indian Creek also discharges into the Piney River. Here too, transportation and drainage control costs would be relatively high.

The Quarry and Whitehead's Hollow would be required for storage of water if the Magnetic Iron Oxide plant were built . These water storage reservoirs should also be kept in reserve in the event that the plant site is to be used for other manufacturing processes and/or if the plant were offered for sale. If a Magnetic Iron Oxide plant is not built, however, then the Existing Tailings Pond would appear to be the most likely candidate for copperas storage, since it is close to the pile, holds water and has sufficient capacity.

2. Preferred Site

ECD and Geraghty and Miller, Inc. personnel have reviewed data on all candidate sites and concluded that either the Existing Tailings Pond or the Quarry is the most suitable site, if the pile is not to be held in reserve for future use for the Magnetic Iron Oxide process. For permanent disposal the Existing Tailings Pond (Item b) would be the location of choice.

The latter location was first suggested by Plant personnel. ECD and Geraghty and Miller, Inc. personnel concur that disposing of the copperas in the Existing Tailings Pond is the preferred alternative.

This 41 acre site has a deep bed of dense tailings material and red clay dams. The pond is 800 ft. from Maple Run Creek and 1500 ft. from the Piney River. No springs exist on this site and the only water entering the pond is from rainfall. Pools of rainwater remain for 5-6 days and disappear seemingly due to evaporation only. This is an indication of the impervious nature of the tailings.

The copperas would be hauled by truck to the higher elevation portion of the Existing Tailings Pond. This distance is about 2 miles. The recommended procedure is to pile the copperas 8 ft. deep over about a 10 acre area, then cover it with at least one foot of red clay to minimize leaching by rainwater. A soil cover to permit growth of vegetation is also recommended for aesthetic purposes. The clay cover should be properly graded to promote rapid runoff of rainfall. Diversion ditches surrounding the clay covered pile should be provided to keep the pile free of stagnant water which could leach the copperas. All runoff should be diverted away from the covered copperas to the lower elevations of the Existing Tailings Pond.

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Contaminants due to leaching of the covered copperas would be contained within the pond. Disposal by evaporation will occur from this remaining 31 acres of pond area. Plant personnel have indicated that the evaporation rate in this area is about equal to the precipitation rate.

The addition of finely crushed limestone for neutralization is not recommended. Pigments Division personnel have conducted experiments with copperas and limestone and found that very limited neutralization occurs, since a coating of calcium sulfate forms on the surface of the limestone and stops the neutralization reaction

Regulatory Acceptance

The possibility of moving the copperas pile to the Existing Tailings Pond has been mentioned during discussions with staff members of VWCB. There is a high probability that the regulatory authorities will accept this alternative as a permanent solution.

Estimated Cost

Estimated cost for using the Existing Tailings Pond for disposal of the copperas pile is $88,500. This cost includes transportation, spreading the copperas and providing a clay cover. Details are given in Table II.

C. Land Reclamation

Disposal of water soluble material by standard landfill practice is not a practical solution. A one-inch thick layer of the copperas would occupy 1033 acres of land, which is not available. This layer would probably kill most, if not all, plant life on the land. Soil erosion and ground water contamination would result and constitute a new environmental problem.

For these reasons this method is rejected.

D. Product Recovery and Reuse

The production of Precursor or Magnetic Iron Oxide would, of course, solve the copperas pile problems. The Virginia Water Control Board has indicated that the construction of a commercial process to consume the copperas would probably receive a more favorable consideration by the Board than other alternatives. Cost estimates for these alternatives were developed in Authorization Estimates prepared by ECD and Pigments Division.

III. Liquid Disposal Methods

A. Continued Leaching and Treatment

At the present leaching rate of about 11-15 gpm the copperas pile should disappear in approximately 40-60 years. A small neutralization/oxidation plant could be built to continuously treat the run-off. Disposal of sludge from the neutralization process is also a problem. This route does not seem attractive due to the time frame involved.

TABLE II

RELOCATION FOR SOLIDS DISPOSAL OR REUSE

Process	Technical Feasibility	Economic Feasibility		Regulatory Acceptance
		Capital Cost	Capital for Preferred Method	
B. Pit Disposal (in quarry)	Poor to Fair			Acceptable with Monitoring and Long Term Guarantee
Transportation @ $.43/ton		$64,500	$	
6" Concrete Cover @ $110/cu.yd. on 136,700 sq.ft.		278,500		
Film Cover @ $.40/sq.ft.		54,700		
Physical Cover (Earth on Film) 3 ft. thick @ $.40/cu.yd.		6,100		
Drainage Control Allowance		20,000		
Tailings Pond Disposal Site	Good			Acceptable with Monitoring and Long Term Guarantee
Transportation @ $.43/ton			64,500	
Spread Copperas over 10 acres			17,500	
10 Acre Red Clay Cover 1 ft. thick @ $.40/cu.yd.			6,500	
Total			88,500	
C. Land Reclamation A one inch layer of copperas requires 1033.1 acres	Not Feasible	High		Not Acceptable
D. Product Recovery and Reuse Precursor	Good to Excell.	1,000,000	1,000,000	Acceptable
Magnetic Iron Oxide	Good to Excell.	2,000,000	2,000,000	Acceptable

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Cyanamid would have to provide a long term guarantee to the State that it would continue to operate the facility and monitor its performance. Monitoring would be needed to demonstrate compliance with the river water quality standards.

B. Accelerated Leaching and Treatment

The run-off rate could be accelerated by pumping water onto the pile. At a run-off rate of 160 gpm, for example, the 150,000 ton pile could be treated by a neutralization/oxidation process within 6 years.

Regulatory Acceptance

The regulatory authorities should accept this approach when accompanied by an adequate monitoring program.

Cost Estimate

The estimated capital cost for an oxidation-neutralization system to treat accelerated leaching effluent is $300,000. To this must be added annual operating costs, which will be quite high (see Table III).

C. Deep Well Disposal

Generalized geological investigations indicate that there are no underlying strata suitable for deep disposal wells. This is confirmed to some extent by the fact that there are no such wells in the area. This method, therefore, would not be technically feasible, and furthermore, it would probably not be acceptable to the State and Federal regulatory agencies.

IV. Ocean Disposal

A. Basic Considerations

At the request of Pigments Division management, ECD investigated the feasibility of ocean disposal of the copperas. Advantage was taken of the similarity between ocean disposal of the Piney River Plant copperas and the planned ocean disposal of aqueous solutions containing copperas from the Savannah Plant.

The disposal of copperas at sea would require:

(1) A technically and economically feasible means of transportation.

(2) Available and suitable barge, docking and loading facilities.

(3) A permit to load and navigate a barge shipment of copperas.

(4) A permit to discharge in the deep ocean.

Mr. F. Schrodt of the Transportation Department provided background information

Barges used to dispose of solids, such as copperas, would be of two types; bottom discharge and clam shell scoop unloading. The bottom discharge type has a hinged bottom with a seam running the length of the bottom. Frequently this seam leaks and some copperas would, therefore, leak into the ocean before reaching a dumping zone. Such a barge could never be used in a river or bay. A barge having a clam shell scoop unloads a portion of the solids by dropping the material overboard. Such a procedure would be slow and costly and extremely dangerous in heavy seas.

TABLE III

LIQUID DISPOSAL METHODS

Process	Technical Feasibility	Economic Feasibility			Regulatory Acceptance
		Capital Cost	Capital for Preferred Method	Chemical Cost for Entire Pile	
1. Continued Leaching and Treatment, at 11-15 GPM Treatment Expected to Take 40-60 yrs. Theoretical Amount of Limestone ($7.5/ton) or Hydrated Lime ($20/ton)	Good to Excellent	$150,000		$405,000 to $800,000 depending on ratio used	Questionable - May Require Long Term Guarantee
2. Accelerated Leaching and Treatment for 6 yrs. in Existing Available Equipment at 160 GPM (Sno-Bird Process)	Good to Excellent	$600,000	$600,000	Same as III - 1 Above	Acceptable
3. Deep Well Disposal	Not feasible in this area	Unknown			Not Acceptable

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B. National Lead Company Barge

National Lead has a standby barge which Cyanamid could offer to purchase or charter. This barge is capable of handling a liquid load only, not solid copperas. To date, conferences with National Lead have indicated that Cyanamid might be able to charter this barge, not purchase it. No costs have been discussed.

The probability of success of this venture is low. National Lead needs a standby barge immediately available due to the hazards of navigating the lower reaches of the Raritan Estuary.

C. DuPont Company Barge

It has been suggested that Cyanamid might utilize the DuPont barge, on an interim basis. The DuPont ocean disposal operation, however, involves the loading of dilute sulfuric acid into a barge at their facility in the Wilmington, Delaware area. No solids or copperas solution are loaded. The barge is towed to their dumping area where the acid is discharged by gravity through valves in the rear of the barge. This operation is not amenable to handling solid copperas, and it is, therefore, highly unlikely that DuPont could accommodate Cyanamid in this fashion.

D. Cooperative Venture

There is another possible but improbable means of ocean disposal of the Piney River copperas. The solid copperas could be transported by rail to Norfolk, Virginia. The copperas could be dissolved in water using available mixing tanks, loaded into the National Lead barge and discharged at the DuPont dump site. This procedure assumes that Cyanamid could charter the National Lead barge, procure mixing and loading facilities at Norfolk and operate under DuPont's barging permit.

Regulatory Acceptance

ECD believes this disposal method to be highly questionable, especially the use of DuPont's barging permit. There is, futhermore, no reason to expect that DuPont would or could accommodate a competitor in this way. ECD does not believe ocean disposal of copperas to be a viable route, and, the costs are high relative to other alternatives.

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